Electronic Characterization of Ultra-thin Fe_3O_4 Films

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Introduction: Transition metal oxides have recently attracted much attention because of their novel electronic and magnetic properties. For example, Fe_3O_4 is proposed to be half-metallic ferromagnet at room temperature, thus it has attracted much attention due to its potential application. In particular, it should be an ideal material for ferromagnetic electrodes in magnetic tunneling junctions (MTJ) because of its predicted 100% spin polarization of conduction electrons. To realize its usefulness in MTJ's, we have studied the electronic and magnetic properties of Fe_3O_4 grown on different thin film heterostructures, which promote textured growth of Fe_3O_4 along different crystallographic directions.

Methods and Materials: The samples were grown by dc magnetron sputtering and were characterized by TEM and MOKE. Both Fe_3O_4 films with 10 Å Al_2O_3 cap layers and uncapped films have been studied. Photoemission spectra of the valence band were collected on each sample at photon energies of 43.5eV and 132.5eV at room temperature and LN_2 temperature, and Fe 3p core level spectra were collected on each sample at a photon energy of 132.5eV.

Results: All films showed the characteristic Verwey transition upon cooling to LN_2, suggesting that a pure Fe_3O_4 phase is grown regardless of the underlying film structure. **Figure 1** shows typical valence band spectra for the uncapped Fe_3O_4 films collected at room temperature. While the valence band spectra collected at hν=132.5eV imply that the films are electronically similar, valence band spectra collected at hν=43.5eV show distinct differences between the (111) and (100) films. Spin-resolved photoemission valence band spectra were also collected at hν=43.5eV. To date, spin polarization smaller than that predicted for half-metallic behavior has been measured and more detailed experiments are underway to understand this discrepancy.

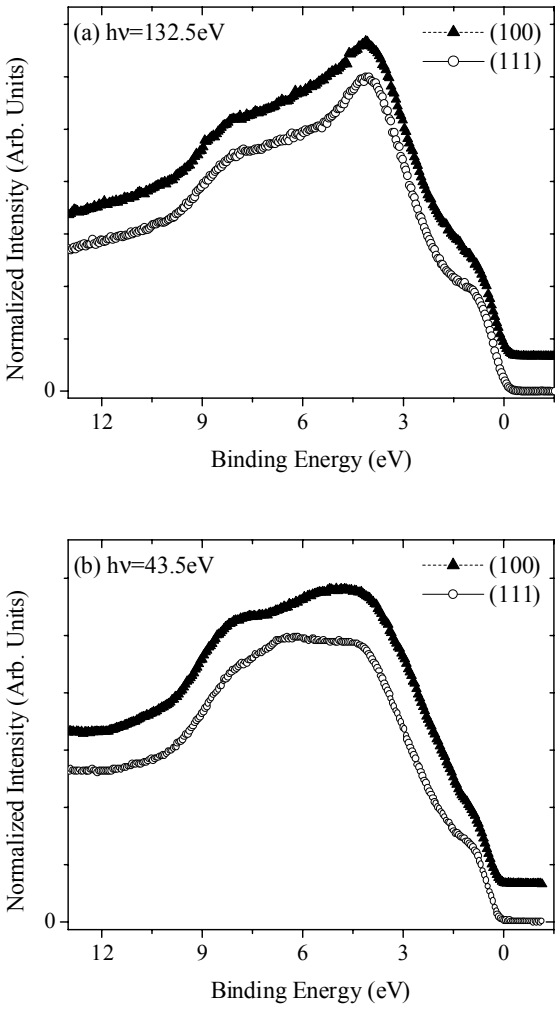

Figure 1. Typical valence band spectra at photon energies of (a) 132.5eV and (b) 43.5eV for (100) and (111) Fe_3O_4 films at room temperature.